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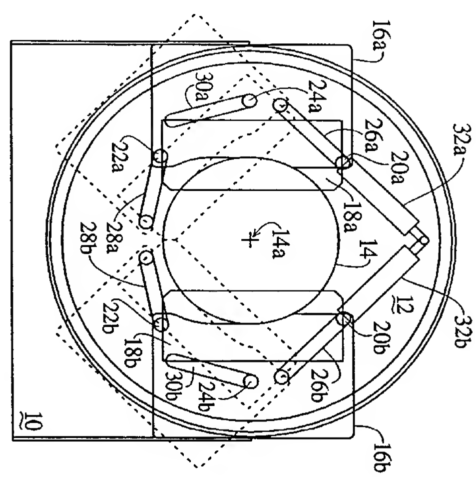
(54) **Nuclear camera systems**

(57) A two head single photon emission computed tomography (SPECT) nuclear camera system has two detector heads (16a, 16b) which are movable between a 180° opposite position and an adjacent, orthogonal position. The detector heads have slide members (42a, 42b) which are slidably received on linear radial guide members (40a, 40b) of carriers (16a, 16b). The carriers have followers (20a, 22a, 24a; 20b, 22b, 24b) which are slidably received along linear guide paths (26a, 28a, 30a; 26b, 28b, 30b). Hydraulic or other extensible cylinders (32a, 32b) selectively permit the carriers, hence the detector heads, to slide along the guide paths between the 180° opposite and the adjacent, orthogonal positions. Preferably, a rotating gantry (12) is rotated to place both detector heads above an intended position. In this manner, the extensible cylinders controllably lower the detector heads as they move by gravity from the present position to the intended position. In both the 180° opposite and the adjacent orthogonal positions, the detector heads concurrently rotate around an axis of rotation (14a) and move radially in and out to minimize the distance between the subject and the detector head.

Fig.2

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## Description

The present invention relates to nuclear medicine camera systems. It finds particular application in conjunction with two head single photon emission computed tomography (SPECT) camera systems and will be described with particular reference thereto.

Early nuclear or Anger cameras had a single radiation detector head which was positioned stationarily over a region of interest of the subject. The subject was injected with a radioactive dye which circulated through the patient's circulatory system. Some of the radiation given off by the dye was received by the nuclear camera head which converted the radiation event into light.

More specifically, the nuclear camera head included a scintillation plate which converted each radiation event into a scintillation or flash of light. An array of photomultiplier tubes positioned in back of the scintillator plate and associated circuitry determined an (x,y) coordinate location and an energy or (z) value for each scintillation event. A collimator including a grid-like array of lead vanes limited the path or trajectory of radiation events which could strike the scintillation plate. Typically, the collimator constrained each incremental element of the scintillator plate to be receptive only to radiation directly in front of it, i.e., radiation along paths substantially perpendicular to the scintillator plate. In this manner, a shadowgraphic image of the frequency of radiation events in the examined region of the subject was developed.

When the detector head was rotated around the subject or indexed to a multiplicity of angularly offset positions around the subject, a data set was collected which is the mathematical equivalent of a CT scanner data set. More accurately, because the nuclear camera head is two-dimensional, a series of data sets were collected which each corresponded to one slice of an imaged volume.

As with CT scanners, rotating the detector head 180° around the subject produced a complete data set. For faster or more detailed imaging, two detector heads have been mounted to the gantry for rotation around the patient. Typically, the two detector heads have been placed 180° opposite to each other. The 180° opposite orientation has numerous advantages. Mechanically, the detector heads and their lead collimators are very massive. By positioning a pair of detector heads opposite to each other, a counterbalance effect is achieved which simplifies or reduces the strength of mechanical bearings, gears, and actuators needed for rotating the gantry. A second advantage resides in the reconstruction process. When the heads are positioned 180° opposite to each other, both heads view the same rays or paths through the subject. This doubles the data acquisition rate and enables data collected by the two heads to be combined in real time for computational efficiency. Of course, when the heads are positioned 180° opposite to each other, 180° of rotation is still required to generate a complete data set.

Rather than placing the two detector heads 180° apart on the gantry, advantages have been achieved by placing the detector heads 90° apart. When two detector heads are placed 90° apart, a complete data set can be collected in only 90° of rotation. Note that during the first 90° of rotation, each detector head is viewing unique rays. After 90° of rotation, each detector head starts receiving data along rays which the other detector head previously sampled.

Regardless whether the detector heads are placed 180° apart or 90° apart, it is advantageous to position the patient as close as possible to the detector head. Because the human torso is generally not circular, the detector heads are typically movable radially from an axis of rotation such that they can follow the contours of the patient's body.

Heretofore, gantries with 180° opposed detector heads have been adapted to reposition the detector heads 90° apart. However, repositioning the detector heads 90° apart has been a relatively complex mechanical movement. After being positioned in the 90° apart position, the heads are not movable radially about the center of rotation. In one system, the heads are so large that they touch at their corners before reaching a minimal spacing from the patient. In another system, the mechanical arrangement which enables the heads to be shifted between 180° and 90° cannot accommodate radial movement. To maintain the minimal patient/detector head spacing in the 90° detector position, the prior art systems move the patient relative to the detector heads. That is, while the detector heads rotate a fixed radius from the center of rotation, the position of the patient is shifted along vertical and horizontal axes to maintain the patient a minimal distance from the detector heads.

The present invention provides a new and improved SPECT camera system which provides the benefits of both 180° opposite and 90° position detector heads.

According to a first aspect of the invention there is provided a SPECT camera system including a stationary gantry, a rotating gantry which selectively rotates about a subject disposed along an axis of rotation, a pair of nuclear camera heads supported by the rotating gantry, and a repositioning means for moving the two detector heads between a 180° opposite position in which the two nuclear camera heads are disposed on diametrically opposite sides of the subject and an adjacent, orthogonal position in which the two detector heads are disposed closely adjacent and orthogonal to each other; characterised by: a radial movement means for moving the two detector heads radially relative to an axis of rotation in both the 180° opposite position and the adjacent, orthogonal position to position the detector heads a minimal proximity from the subject without moving the subject radially relative to the axis of rotation.

Preferably the repositioning means includes guide paths for each detector head, the guide paths being defined along the rotating gantry, and followers for movement along the guide paths mounted for movement with

each detector head, and a means for selectively controlling sliding movement of the followers through the guide paths.

Suitably each of the detector heads is supported by a carrier, the repositioning means being connected with the carriers for moving both the carriers and the supported detector heads relative to the rotating gantry.

In accordance with a second aspect of the invention there is provided a method of positioning detector heads of a dual head SPECT camera in which the heads are selectively moved between a 180° opposite position in which the detector heads are disposed diametrically opposite across a subject and facing each other and an adjacent, orthogonal position in which the two detector heads are disposed closely adjacent and face the subject in directions orthogonal to each other, characterised by: concurrently rotating the detector heads around an axis of rotation in the adjacent, orthogonal position and moving the detector heads radially relative to the axis of rotation.

Preferably the moving step includes: with the detector heads in the 180° opposite position, positioning the detector heads at substantially 3 o'clock and 9 o'clock; and controllably permitting gravity to lower the detector heads from the 180° opposite position to the adjacent and orthogonal position.

Preferably the method further includes rotating a rotating gantry on which the detector heads are mounted such that the detector heads in the adjacent and orthogonal position are substantially at an uppermost position; and controllably allowing gravity to lower the detector heads from the adjacent and orthogonal position to the 180° opposite position.

One advantage of the present invention is that it facilitates repositioning the detector heads.

Another advantage of the present invention is that it uses gravity to assist the repositioning and enables mechanical components to be lighter-weight and more compact.

One camera system and method in accordance with the invention will now be described, by way of example, with reference to the accompanying drawings in which:-

FIGURE 1 is a diagrammatic, front view of the camera system with its detector heads 180° opposite in solid line and in an adjacent, orthogonal position in phantom;

FIGURE 2 is a diagrammatic illustration of a mechanical linkage of the camera system for moving the detector heads between the 180° opposite position shown in solid lines and the adjacent, orthogonal position shown in phantom;

FIGURE 3 is a diagrammatic illustration of the linkage with the detector heads in the adjacent, orthogonal orientation shown in solid line and the 180° opposite orientation shown in phantom; and,

FIGURE 4 is a side view in partial section of the camera system with the detector heads in the 180° opposite position and oriented at 12 o'clock and 6 o'clock.

Referring to Figure 1, the system includes a stationary gantry portion 10 which supports a rotating gantry 12 for rotation about an axis of rotation 14a at the center of an examination region 14. The rotating gantry carries a pair of detector head carriers 16a, 16b, each of which carry a detector head 18a, 18b, respectively.

Each detector head includes a scintillation plate facing orthogonal to the region of interest 14 and an array of photodetectors for monitoring the scintillation plate for scintillations. A collimator is mounted between the scintillation plate and the examination region. The photodetectors are connected with circuitry for resolving (x,y) coordinates of each scintillation event. An angular position resolver means determines the angular position of the detector heads around the examination region and a radial position resolver determines a radial displacement of each detector head from the center of the examination region. From the (x,y) coordinate positions on the detector heads, the angular orientation and the radial position of the detector heads,a three-dimensional reconstruction means reconstructs a three-dimensional image representation of the subject for display on a video monitor or the like.

To move the detector heads from the 180° opposite orientation (FIGURE 2) to the adjacent, orthogonal position (FIGURE 3), the detector heads are preferably positioned at 3 o'clock and 9 o'clock. Gravity urges followers 20a, 22a, 24a on the carrier plate 16a to slide along linear guide paths 26a, 28a, 30a, respectively, in the rotating gantry 12. Analogously, followers 20b, 22b, and 24b connected with the carrier 16b are urged to slide along linear guide paths 26b, 28b, and 30b, respectively. A pair of hydraulic cylinders 32a, 32b are electronically controlled to limit the rate at which the detector head carriers 16a, 16b move between the oppositely disposed and adjacent, orthogonal positions.

The hydraulic cylinders slowly extend, allowing the detector head carriers and detector heads to move under the force of gravity and the urging of the hydraulic cylinders from the 180° opposite of FIGURE 2 to the adjacent, orthogonal position of FIGURE 3. In the orthogonal position, the heads are off center from the axis of rotation. Planes 34a and 34b that are perpendicular to a central axis of the heads' radiation receiving faces intersect along a line 36. The line 36 is further from the radiation receiving faces than the axis of rotation 14a.

To return the detector heads from their adjacent, orthogonal position to the 180° opposite position, the gantry is preferably rotated 180° placing the detector heads adjacent the top of the gantry. The hydraulic cylinders then control the gradual lowering of the detector heads and carriers back to the 180° opposite position of FIGURE 2. Alternately, the rotatable gantry can be rotated 90° from the position illustrated in FIGURE 2 and one of

the heads lowered, and then rotated in the opposite direction and the other head lowered. In the 180° opposition position, the center lines of the detector faces and the axis of rotation are in a common plane.

With reference to FIGURE 4, each of the carriers include a plurality of linear guide members 40a, 40b which extend substantially parallel to a radial direction from the axis of rotation 14a. Each of the detector heads include a plurality of slide members 42a, 42b which slide along the linear guide members 40. A drive means, such as a worm drive and follower (not shown) selectively adjust the displacement of each detector head radially relative to the axis of rotation. In operation, a subject is positioned with the axis of rotation extending along a central axis of the subject. The detector heads concurrently rotate about the axis of rotation and move radially in and out to minimize a distance between the detector face and the subject.

## Claims

1. A SPECT camera system including a stationary gantry (10), a rotating gantry (12) which selectively rotates about a subject disposed along an axis of rotation (14a), a pair of nuclear camera heads (18a, 18b) supported by the rotating gantry (12), and a repositioning means (20 to 32) for moving the two detector heads (18a, 18b) between a 180° opposite position in which the two nuclear camera heads (18a, 18b) are disposed on diametrically opposite sides of the subject and an adjacent, orthogonal position in which the two detector heads (18a, 18b) are disposed closely adjacent and orthogonal to each other, characterized by: a radial movement means (40, 42) for moving the two detector heads (18a, 18b) radially relative to an axis of rotation (14a) in both the 180° opposite position and the adjacent, orthogonal position to position the detector heads (18a, 18b) a minimal proximity from the subject without moving the subject radially relative to the axis of rotation (14a).

2. A SPECT camera system as set forth in claim 1, wherein: the repositioning means (20 to 32) includes guide paths (26, 28, 30) for each detector head (18a, 18b), the guide paths (26, 28, 30) being defined along the rotating gantry (12), and followers (20, 22, 24) for movement along the guide paths (26, 28, 30) and mounted for movement with each detector head (18a, 18b) and means (32) for selectively controlling sliding movement of the followers (20, 22, 24) through the guide paths (26, 28, 30).

3. A SPECT camera system as set forth in claim 1 or claim 2 wherein the repositioning means includes at least two linear guide paths (26, 28, 30) associated with each detector head (18a, 18b) and a follower (20, 22, 24) for each linear guide path (40).

4. A SPECT camera system as set forth in any preceding claim wherein each of the detector heads (18a, 18b) is supported by a carrier (16a, 16b), the repositioning means (20 to 32) being connected with the carriers (16a, 16b) for moving both the carriers (16a, 16b) and the supported detector heads (18a, 18b) relative to the rotating gantry (12).

5. A SPECT camera system as set forth in claim 4 wherein the radial movement means (40, 42) includes linear guide members (40) mounted to each carrier (16a, 16b) radially of the examination region, slide means (42) on each detector head (18a, 18b) for sliding movement along the linear guide members (40) mounted on the associated carrier (16a, 16b), and means for selectively sliding each detector head (18a, 18b) and slide means (42) along the linear guide members (40) mounted on the associated carrier (18).

6. A method of positioning detector heads (18a, 18b) of a dual head SPECT camera in which the heads (18a, 18b) are selectively moved between a 180° opposite position in which the detector heads (18a, 18b) are disposed diametrically opposite across a subject and facing each other and an adjacent, orthogonal position in which the two detector heads (18a, 18b) are disposed closely adjacent and face the subject in directions orthogonal to each other, characterized by: concurrently rotating the detector heads (18a, 18b) around an axis of rotation (14a) in the adjacent, orthogonal position and moving the detector heads (18a, 18b) radially relative to the axis of rotation (14a).

7. A method as set forth in claim 6 wherein the moving step includes: with the detector heads (18a, 18b) in the 180° opposite position, positioning the detector heads (18a, 18b) at substantially 3 o'clock and 9 o'clock; and controllably permitting gravity to lower the detector heads (18a, 18b) from the 180° opposite position to the adjacent and orthogonal position.

8. A method as set forth in claim 6 or claim 7 further including: rotating a rotating gantry (12) on which the detector heads (18a, 18b) are mounted such that the detector heads (18a, 18b) in the adjacent and orthogonal position are substantially at an uppermost position; and controllably allowing gravity to lower the detector heads (18a, 18b) from the adjacent and orthogonal position to the 180° opposite position.

9. A method as set forth in claim 6, claim 7 or claim 8 wherein the detector heads (18a, 18b) movably mounted on carriers (16a, 16b) and the step of mov-

ing the detector heads (18a, 18b) between the 180° opposite and the adjacent, orthogonal positions includes moving the carriers (16a, 16b) relative to a rotating gantry portion (12) on which the detector heads (18a, 18b) are supported.

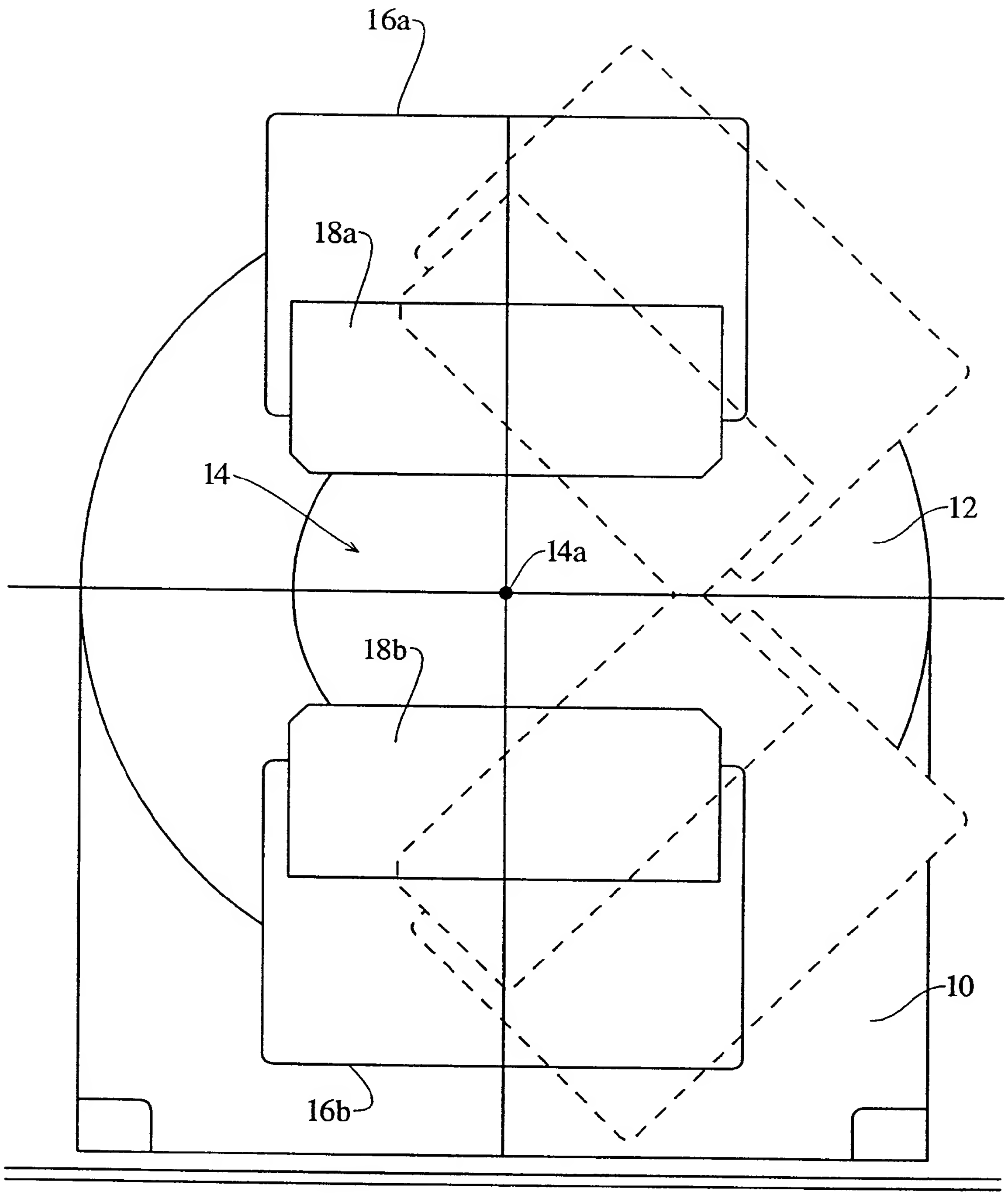


Fig.1

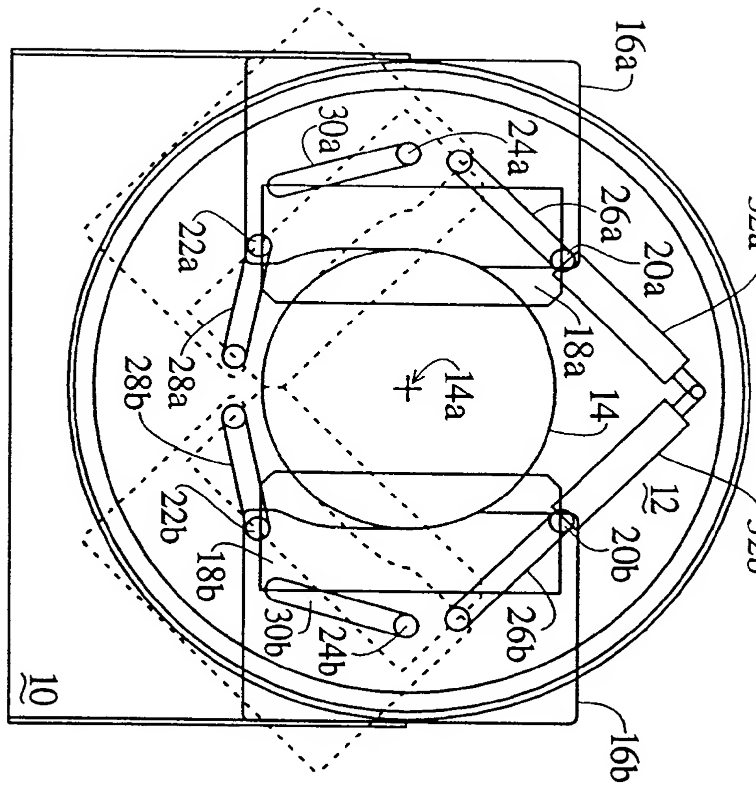
16a
32a
24a
26a
20a
30a
22a
18a
14a
14
28a
28b
12
32b
22b
20b
18b
26b
30b
24b
10
16b

Fig.2

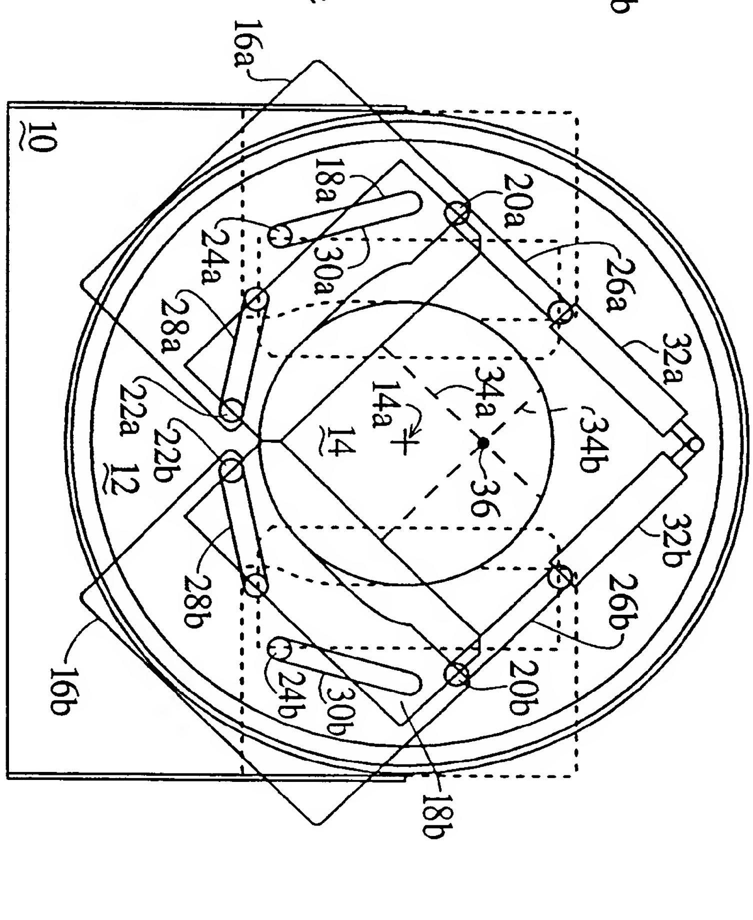
16a
10
18a
20a
24a
30a
26a
28a
32a
34a
14a
14
34b
22a
22b
12
36
32b
28b
26b
24b
30b
20b
16b
18b

Fig.3

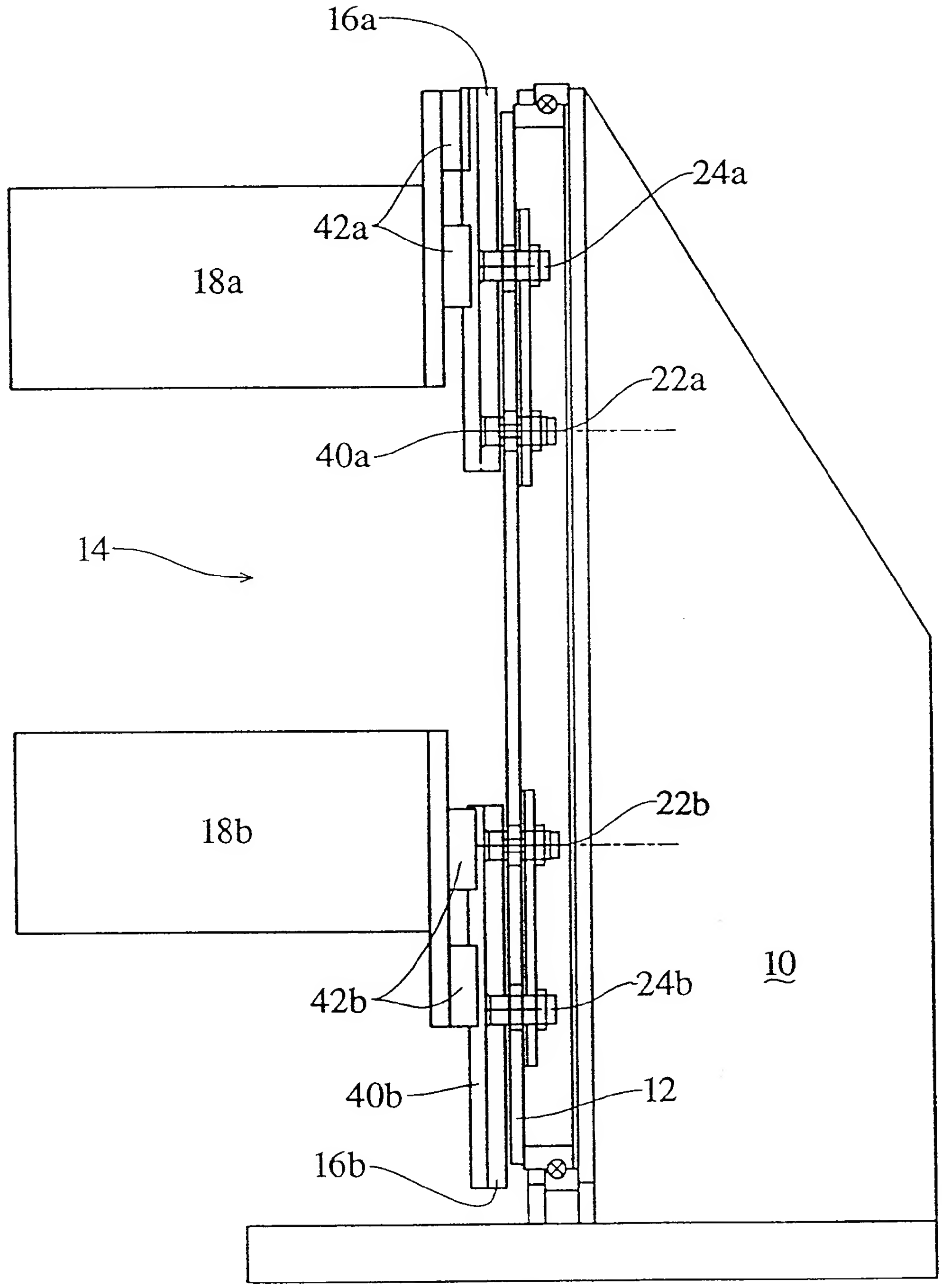


Fig.4

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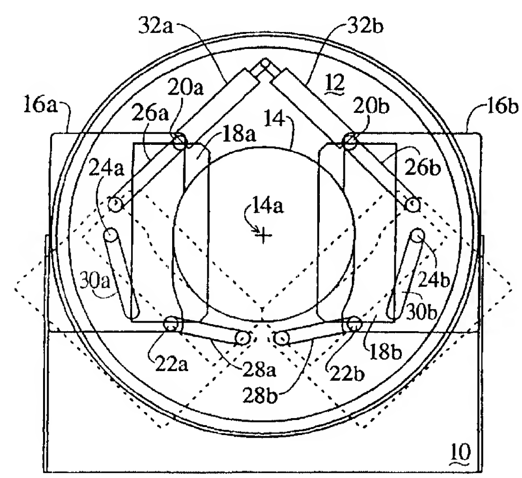


Fig.2

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European Patent Office

# EUROPEAN SEARCH REPORT

Application Number
EP 95304969.9

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int. Cl. 6) |
|---|---|---|---|
| X | EP 0532152 A1 (ADAC LABORATORIES) 17 March 1993 (17.03.93), the whole document. | 1,6,9 | G 01 T 1/166<br>A 61 B 6/03<br>G 01 T 1/29 |
| A | -- | 2-5,7,8 | |
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| A | -- | 2-9 | |
| A | US 5039859 A (SANZ et al.) 13 August 1991 (13.08.91), claim 11, fig. 1,2. -- | 1-9 | |
| A | US 4204123 A (STODDART) 20 May 1980 (20.05.80), fig. 4(a),4(b),9-9(n), 10(a)-10(d). ---- | 1-9 | |

TECHNICAL FIELDS SEARCHED (Int. Cl.6)

A 61 B 6/00
G 01 T 1/00

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| VIENNA | 16-12-1997 | WERNER |

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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E : earlier patent document, but published on, or after the filing date
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